

**Work Address**

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**RESEARCH INTERESTS**

- quantum circuits models for quantum computing; quantum logic synthesis
  - applications of Lie theory
  - numerical analysis and simulation ( $< 14$  qubits)
  - synthesis exploiting quantum measurement as a gate
- multi-partite entanglement theory and implications for circuit design

**EXPERIENCE**

Title/Program	Employer	Years
National Research Council (NRC) Postdoc, mathematics	National Institute of Standards and Technology	Summer2003-present
Term Assistant Professor, mathematics	University of Michigan	Fall2000-Summer2003
Teaching-Research Assistant	Cornell University	Fall98-Spring00
Teaching Assistant	Notre Dame University	1996-97 academic year
Teaching Assistant	Cornell University	Fall94-Spring96

**EDUCATION**

Degree	University	Awarded	comment
Ph.D.	Cornell University	May, 2000	mathematics, under Birgit Speh
M.A.	Cornell University	August, 1996	differential geometry
B.S.	University of Georgia	June 1994	summa cum laude, $\Phi\beta\kappa$

**MATHEMATICAL SPECIALTIES****Lie Groups, Lie Theory**

- Structure theory of real groups, Satake & Vogan diagrams, representation theory
- Locally symmetric Riemannian manifolds

**Riemannian geometry and smooth topology**

- de Rham cohomology, sheaf cohomology, Lie algebra cohomology, Hodge theory
- nonpositive curvature, esp. locally symmetric Riemannian manifolds

## PUBLISHED ARTICLES

- [12] S.S. Bullock, D.P. O’Leary, and G.K. Brennen, Asymptotically Optimal Quantum Circuits for  $d$ -level Systems, *Physical Review Letters* **94** 230502 (2005).
- [11] S.S. Bullock, G.K. Brennen, D.P. O’Leary, Time Reversal and  $n$ -qubit Canonical Decompositions. *Journal of Mathematical Physics* **46** 062104 (2005).
- [10] G.K. Brennen, D.P. O’Leary, and S.S. Bullock, Criteria for Exact Qudit Universality. *Physical Review A* **71** 052318 (2005).
- [9] G.K. Brennen, S.S. Bullock, Stability of Global Entanglement in Thermal States of Spin Chains. *Physical Review A* **70** 052303 (2004).
- [8] S.S. Bullock, Note on the Khaneja Glaser Decomposition. *Quantum Information and Computation* **4(5)** 396 (2004).
- [7] V.V. Shende, S.S. Bullock, I.L. Markov, Recognizing Small-Circuit Structure in Two-Qubit Operators. *Physical Review A* **70** 012310 (2004).
- [6] V.V. Shende, I.L. Markov, S.S. Bullock, On Universal Gate Libraries and Generic Minimal Two-qubit Quantum Circuits. *Physical Review A* **69** 062321 (2004).
- [5] S.S. Bullock, G.K. Brennen, Canonical Decompositions of  $n$ -qubit Quantum Computations and Concurrence. *Journal of Mathematical Physics* **45(6)** 2447 (2004).
- [4] S.S. Bullock, I.L. Markov, Smaller Circuits for Arbitrary  $n$ -qubit Diagonal Computations. *Quantum Information and Computation*, **4(1)** 027 (2004).
- [3] S.S. Bullock, I.L. Markov, An Arbitrary Two-qubit Computation in 23 Elementary Gates. *Physical Review A* **68** 012318 (2003).
- [2] S.S. Bullock, Unreduced Gaussian weighted  $L_2$  cohomology of locally symmetric spaces. *New York Journal of Mathematics* **8** 241 (2002).
- [1] S.S. Bullock, Weighted  $L_2$  cohomology of asymptotically hyperbolic manifolds. *New York Journal of Mathematics*, **7** 7 (2001).

## DRAFTS

- [a] Vivek V. Shende, Stephen S. Bullock, Igor L. Markov, Synthesis of quantum logic circuits, <http://www.arxiv.org/abs/quant-ph/0406176>, to appear in *IEEE Transactions on Computer Aided Design*
- [b] Dianne P. O’Leary, Stephen S. Bullock, QR factorizations using a restricted set of rotations, <http://math.nist.gov/~SBullock>, submitted to *Electronic Transactions on Numerical Analysis*

## SERVICE

- [I] Organized NIST MCSD *Quantum Information Theory and Practice Seminar* (QITaP) from September 2004 to June 2005.
- [II] Reviewer for APS *Physical Review A*, *Physical Review Letters*, and (infrequently) *IEEE Transactions on CAD*

## INVITED TALKS & COMPUTER SCIENCE CONFERENCE PAPERS

Title	Coauthors	Venue	Date
Quantum Circuit Design		NRC Board of Assessment of NIST Programs	January 13, 2005
Matrix decompositions & quantum circuit design	Vivek Shende (a) Igor Markov (a)	2 <sup>nd</sup> Feynman Festival	August 21, 2004
Time-reversal symmetry and entangled eigenstates	Gavin Brennen (p) Dianne O’Leary (a)	UMdCP Quantum Info. & Coherence Seminar	May 4, 2004
Time-reversal symmetry and concurrence dynamics	Gavin Brennen Dianne O’Leary	NIST QuIBEC seminar, radiation physics	April 21, 2004
“Entanglement Capacity of $n$ -qubit Quantum Computations”	Gavin Brennen	SPIE symposium, QC&Iii www.spie.org	April 13, 2004
“Finding Small Two-qubit Circuits”	Igor Markov Vivek Shende	SPIE symposium, QC&Iii www.spie.org	April 14, 2004
Time-reversal and the CCD matrix decomposition	Gavin Brennen Dianne O’Leary	NIST QuITaP seminar Math.Comp.Sci.Div.	March 25, 2004
KAK decompositions & entanglement dynamics	-	Cornell Lie Theory seminar	March 5, 2004
Gaussian weighted $L_2$ cohomology	-	Loc.Sym.Space Conf. M.F.Oberwolfach	Oct. 3, 2003
Symmetry Groups of the $n$ -tangle and Maximal Concurrence	Gavin Brennen	Institute for Defense Analyses, CSS	Sept. 8, 2003
“An Arbitrary Two-Qubit Quantum Computation in 23 gates”	Igor Markov	Design Automation Conf. (www.dac.com)	July 2003 <b>B.P.A. nominee</b>
Weighted $L_2$ cohomology	-	AMS midwest section meeting, d.g. session	March 2002

## COMPUTER SKILLS

Proficient with [i] L<sup>A</sup>T<sub>E</sub>X 2<sub>ε</sub>, [ii] C++, [iii] MatLab, [iv] Linux

## REFERENCES

Isabel Beichl (supervisor) .....isabel.beichl@nist.gov  
 Birgit Speh (thesis adviser, pure mathematician) .....speh@math.cornell.edu  
 Dianne O’Leary (applied mathematician) .....oleary@cs.umd.edu  
 Igor Markov (computer scientist) .....imarkov@eecs.umich.edu  
 Bei Lok Hu (physicist) .....hub@physics.umd.edu

## MISCELLANY

Hobbies: jogging, investing, vegetable gardening.

Languages: English, German

Citizenship: USA